

## A LUNAR BASE FOR SETI?

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The proposed NASA search for extraterrestrial intelligence (SETI) will have two search modes.

1. An all-sky survey covering the frequency range from 1 to 10 GHz
2. A high-sensitivity targeted search listening for signals from the  $\sim 800$  solar-type stars within 80 light-years of the Sun, and covering 1 to 3 GHz

Both modes will use existing antennas: 34-m antennas of the Deep Space Network for the sky survey and large radio astronomy antennas such as the NAIC facility at Arecibo, Puerto Rico, for the targeted search.

The frequency ranges of the search are determined by the microwave window. In free space, this window extends from about 1 GHz to 100 GHz and is limited on the low end by rapidly rising synchrotron radiation from the galaxy and on the high end by quantum noise as shown in figure 1. In the silent valley between these two noises, a third noise source sets the floor at 2.76 K. This is the microwave background – the relict radiation from the big bang.

On Earth, noise is added by the absorption lines of water and oxygen as shown in figure 2. The effect is to raise the floor to about 8 K and to reduce the upper limit of the window to 10 GHz. This reduction is not considered to be serious because there are many reasons for preferring the low end of the window anyway.

The nominal range limit of an SETI system is given by

$$R = \frac{d}{4} \sqrt{\frac{P}{N}}$$

where  $R$  = range limit

$d$  = antenna diameter

$P$  = effective isotropic radiated power

$N$  = receiver noise power

We will reduce  $N$  as much as possible by using maser or cooled HEMT receivers and by operating in the microwave window. There is nothing we can do about the power  $P$  that they radiate. If the proposed search fails, it will be necessary to increase  $d$  and hence the antenna collecting area. To do this, one can use

1. Ground-based phased arrays
2. Large shielded antennas in space
3. Lunar arrays
4. Lunar crater Arecibo-type antennas

Let us now consider these alternatives.

1. Ground-based phased arrays

- Are easily serviced and repaired
- Can be fairly well shielded from radiofrequency interference (RFI) (except for satellites)
- Present no unsolved technical problems
- Are smoothly expandable up to  $d > 10^4$  m
- Are much cheaper than other alternatives (if SETI must bear entire cost)

Therefore, our first conclusion is that SETI does not require a lunar base.

2. Large antennas in space

- Need only half the area (noise floor is less)
- Can probably be lightweight
- Present technological problems of construction, transport, and deployment
- Must be shielded from RFI
- Are expandable only in discrete steps
- Require very expensive maintenance and servicing
- Require broadband data link

Shielding of the antenna from strong Earth-based RFI is an unresolved, serious problem. The high cost of servicing makes this alternative unattractive. Antennas should be located close to the permanent maintenance base.

3. Lunar arrays

- Can use larger elements than on Earth because of  $1/6g$  and no wind
- Require half the area of an Earth-based array
- Must be on far side
- Require data link with relay station

4. Lunar crater "Arecibo" arrays (See fig. 3.)

- Offer possibility of cheaper construction
- Need many antennas to get full sky coverage
- Require half the area of Earth-based array

- Must be on far side
- Require data link with relay station

All space alternatives present problems not found in ground-based arrays. The logistics of launch, deployment, and servicing add greatly to the cost. Lunar-based antennas on the far side are probably the most expensive solution of all and are out of the question if SETI must pay the bill. If there is a far-side base for other reasons, the incremental cost of adding SETI might be reasonable.

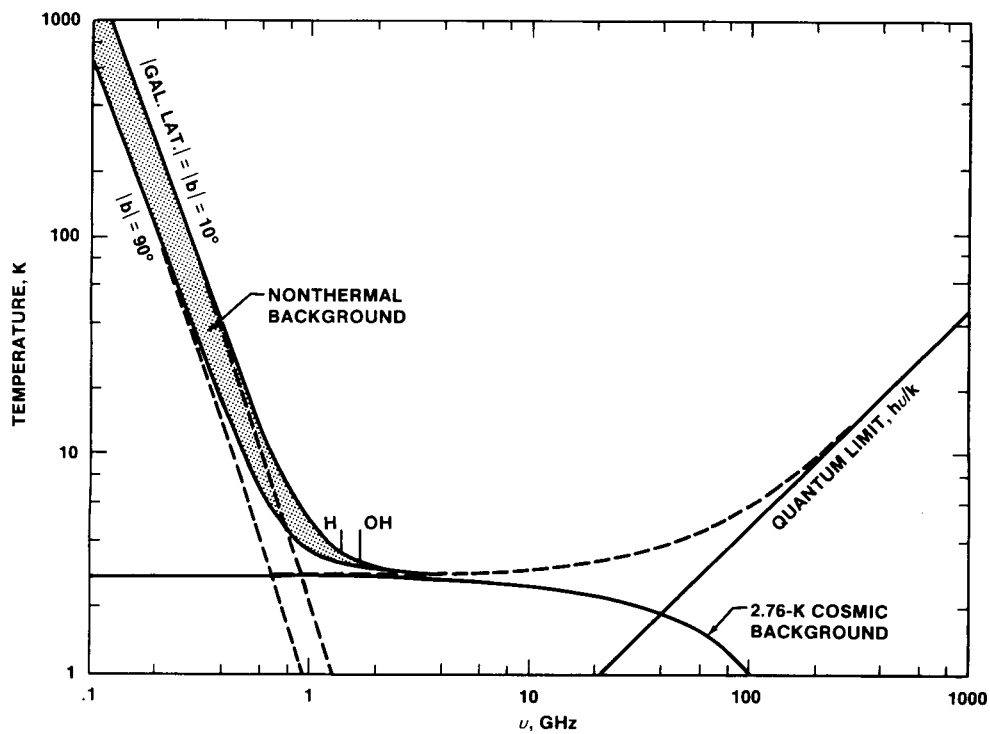


Figure 1.- Free-space microwave window.

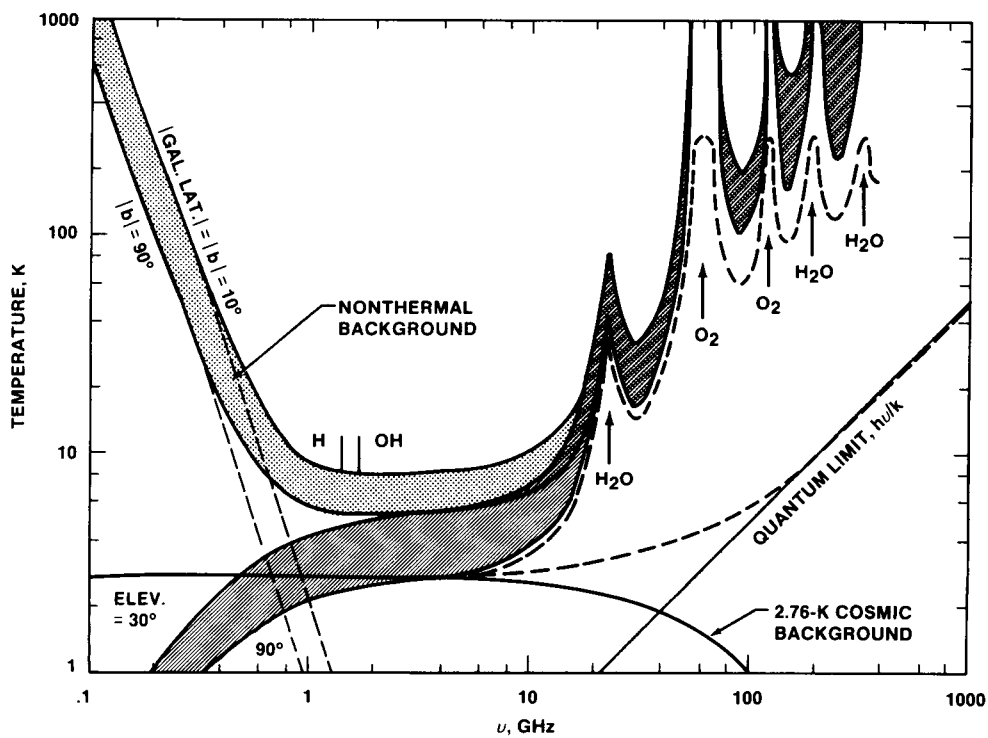


Figure 2.- Terrestrial microwave window.

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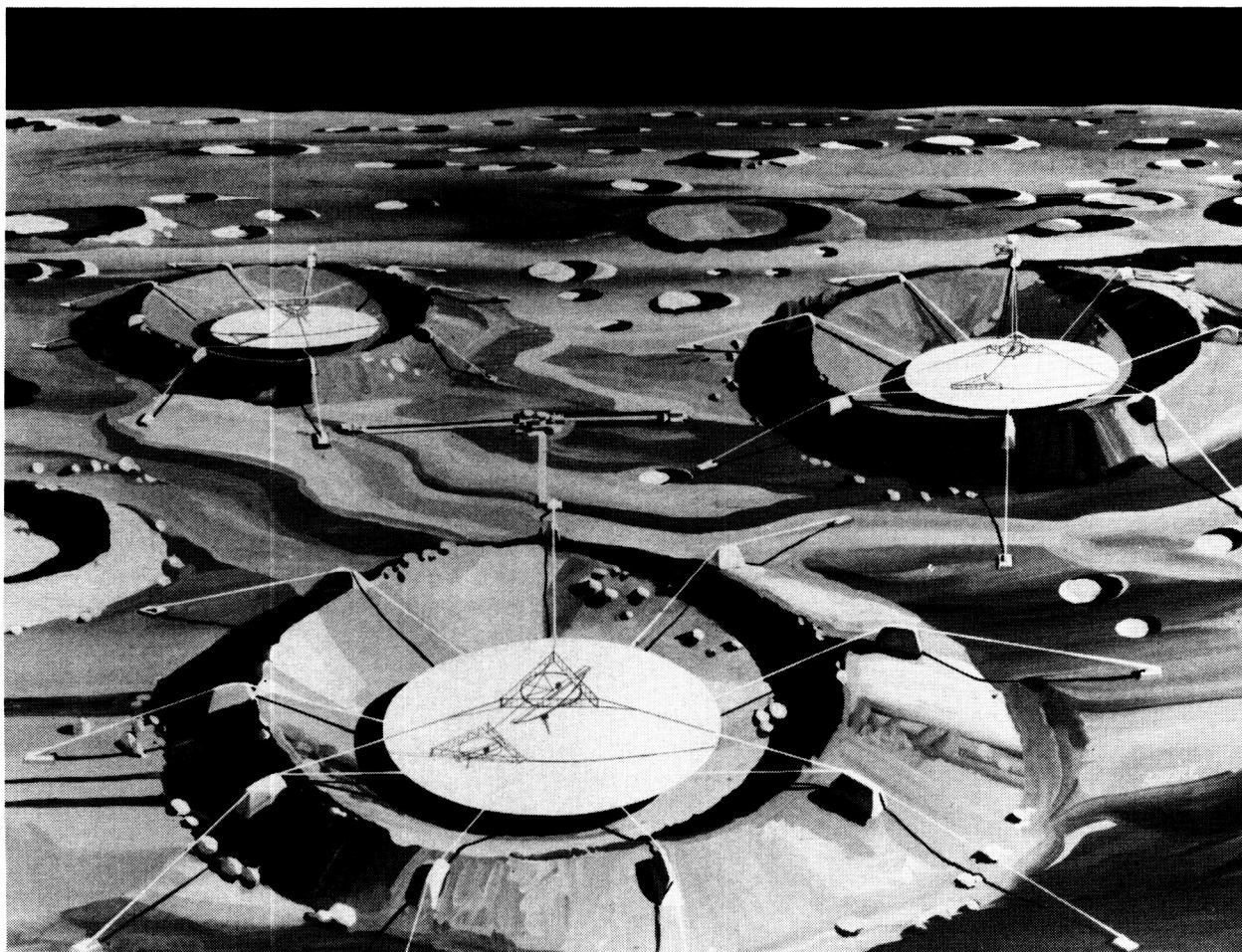


Figure 3.- Artist's concept of an array of three Arecibo-type spherical antennas constructed within natural craters on the far side of the Moon.

**PART IV**  
**ENGINEERING CONSIDERATIONS FOR LUNAR BASE OBSERVATORIES**

In the final section and paper of these proceedings, the practical aspects of building lunar telescopes are considered from the engineering point of view. S. W. Johnson, a pioneer in lunar facilities designs, discusses the engineering considerations and issues to be resolved in further deliberations on lunar-based observatories. In this paper, the desires of the astronomical community are considered together with the practicality of physical constraints for construction on the lunar surface.

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